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The effect of firm-level productivity on exchange rate pass-through

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HIGHLIGHTS

- A decrease in trade costs changes the composition of exporters.
- This change in exporters can explain why exchange rate pass-through is decreasing.
- This study finds evidence in support of this explanation.
- This letter finds that lower-productivity firms have lower exchange rate pass-through.

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ABSTRACT

A heterogeneous-firm trade model can explain the recent decrease in exchange rate pass-through to aggregate US import prices as a result of decreased trade costs. This paper finds support for this explanation by testing another implication of this type of heterogeneous firm model: lower exchange rate pass-through for goods that are traded for short periods of time.

1. Introduction

The effect of exchange rates on international prices dictates the magnitude of adjustment to the current account and international transmission of inflation. Since the 1980s, prices of traded goods have become less responsive to exchange rates. For US imports, *exchange rate pass-through*,[1] the elasticity of the consumer-currency price of an import with respect to the domestic currency price of the foreign currency, has decreased from 50% to 20% (Campa and Goldberg, 2005). This paper finds evidence in support of a heterogeneous firm explanation for this recent decline.

A Melitz (2003)-style model of heterogeneous firms predicts that a change in trade conditions causes a change in the variety of goods that are traded. When trade costs decrease, some firms that were not previously able to export will now be able to do so. These new exporters have lower productivity (or equivalently higher marginal cost) than the firms that were exporting prior to the decrease in trade costs. Heterogeneous firm models with endogenous markups also predict that exchange rate pass-through will vary with productivity.

The pricing behavior of these new, lower-productivity exporters determines how aggregate pass-through to US import prices changes following a global decrease in trade costs. An appreciation of the exporter's currency increases the marginal cost of selling abroad. This increase in cost will partly pass through to prices and partly be absorbed into the exporters' markups. Current theoretical work is ambiguous about whether lower- or higher-productivity firms will pass through more of the change in cost.

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[1] There is a vast literature on exchange rate pass-through (see Goldberg and Knetter (1997) for an excellent survey). For the United States, it is typically found that the US Dollar (USD) price of imports changes by about 20% of the change in the exchange rate and the foreign currency price of exports responds by around 90%.

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This letter makes use of confidential data from the Bureau of Labor Statistics (BLS) to test for pass-through differences between items from low- and high-productivity firms. The BLS computes publicly available price indexes for US imports and exports. The micro-level data used to construct these indexes are collected using voluntary surveys. When the BLS samples an item, it is intended to be in the index for five years. This data set is unique in that the reason the items leave the index is recorded. The heterogeneous firm literature tells us that we can use item longevity to separate items into groups of lower and higher average productivity. Items that do not leave the index early have higher average productivity, while those that stop being traded have lower average productivity. The BLS data allow us to identify items that stop being traded from those that are replaced by a new, similar model. The high-productivity items include roughly 30% of the market transactions in the sample, while low-productivity items include roughly 19%.

This is the first study to test if the pass-through of US imports and exports differs by productivity. This letter finds that pass-through is lower for low-productivity items. An appreciation of the exporter's currency increases the marginal cost of selling abroad. A lower-productivity (and thus higher-price) exporter is not able to raise its price by as much as a lower-price exporter.

The most relevant empirical work is Berman et al. (2012). These authors use estimated total factor productivity for French exporters to find that lower-productivity exporters exhibit greater exchange rate pass-through. The results presented by this letter find the opposite. A possible reason for the difference in conclusions is Berman et al.'s use of firm unit values instead of transaction prices. If firms change their exports following changes in trade conditions, unit values provide a biased estimate of transaction prices.

Section 2 briefly discusses heterogeneous firm models. In Section 3, we describe the data and how items are separated into low- and high-productivity. Section 4, presents differences in exchange rate pass-through between low- and high-productivity items. Section 5 concludes.

2. Heterogeneous firms

In a Melitz-style trade model, a continuum of monopolistically competitive firms draw their productivity from a distribution with a positive skew. (The Pareto distribution is a common choice.) A foreign exporter with productivity φ chooses price p to maximize profits, given by

$$\pi = p\,Q(p, \overline{p}, N) - \frac{\varepsilon \tau W}{\varphi} Q(p, \overline{p}, N) - \varepsilon C,$$

where Q is the demand function which may depend on the average price in the market, $\overline{p}$, and the mass of firms selling in the market, N, ε is the domestic cost of foreign currency, τ is an iceberg trade cost, W is the cost of inputs, and C is a fixed cost. Firms only export when they obtain positive profit form doing so. As trade costs increase, the cutoff level for exporting increases and the lowest-productivity exporters stop exporting.

A non-exiting firm's change in price following a change in the exchange rate depends on how much the firm adjusts its markup. The price that maximizes an exporter's profits is

$$p(\varphi) = \left(\frac{\eta}{\eta - 1}\right) \frac{\varepsilon \tau W}{\varphi}, \tag{1}$$

where η is the (positive) elasticity of demand.

By taking the total derivative of Eq. (1), we find firm-level exchange rate pass-through, denoted ξ, to be[2]

$$\xi(\varphi) \equiv \frac{\mathrm{d}p}{\mathrm{d}\varepsilon}\left(\frac{\varepsilon}{p}\right) = \frac{\eta(\eta-1)^2 - \varepsilon K}{\eta(\eta-1)^2 + p(\eta-1)\eta_p} \tag{2}$$

where η_p is the partial derivative of the elasticity of demand with respect to price. The term

$$K \equiv \left(\frac{\partial \eta}{\partial \overline{p}}\right)\frac{\mathrm{d}\overline{p}}{\mathrm{d}\varepsilon} + \left(\frac{\partial \eta}{\partial N}\right)\frac{\mathrm{d}N}{\mathrm{d}\varepsilon}$$

is a measure of the change in the elasticity of demand that follows from a change in the competitive environment.

A model with quadratic preferences (as in Melitz and Ottaviano (2008)) predicts that lower-productivity firms will pass through more of a change in the exchange rate, while a model with translog preferences (as in Rodriguez Lopez 2011) predicts that higher-productivity firms will pass through more.

Trade costs affect the firms' cost of exporting and change the composition of firms. Letting F and f denote the CDF and PDF of the Pareto distribution with shape parameter α, we can use Leibniz's rule to decompose the effect of changing trade costs on aggregate pass-through in to the average effect on firms and the effect on the change in the composition of firms as

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}\tau}\int_{\varphi^*}^{\infty}\xi(\varphi)\,\mathrm{d}F(\varphi|\varphi\ge\varphi^*) &= \int_{\varphi^*}^{\infty}\frac{\mathrm{d}}{\mathrm{d}\tau}\left[\xi(\varphi)f(\varphi|\varphi\ge\varphi^*)\right]\mathrm{d}\varphi \\ &\quad - \xi(\varphi^*)f(\varphi^*|\varphi\ge\varphi^*)\frac{\mathrm{d}\varphi^*}{\mathrm{d}\tau} \\ &= \underbrace{\int_{\varphi^*}^{\infty}[\mathrm{d}\xi(\varphi)/\mathrm{d}\tau]\,\mathrm{d}F(\varphi|\varphi\ge\varphi^*)}_{\text{Average firm—level effect}} \\ &\quad + \underbrace{\frac{\alpha}{\varphi^*}\frac{\mathrm{d}\varphi^*}{\mathrm{d}\tau}\left[\overline{\xi(\varphi)} - \xi(\varphi^*)\right]}_{\text{Composition effect}},\end{aligned} \tag{3}$$

where $\overline{\xi(\varphi)}$ is the average exchange rate pass-through and φ^* is the cutoff level of productivity for exporting. The composition effect is increasing in the shape parameter α (as this implies greater entry or exit) and in the relative change in the cutoff level $(\mathrm{d}\varphi^*/\mathrm{d}\tau)/\varphi^*$. For a model with translog preferences, the compositional effect of a decrease in trade costs dominates the firm-level effect and aggregate exchange rate pass-through decreases. A model with quadratic preferences predicts an increase in pass-through following a decrease in trade costs. (The derivation of these results are in the appendix of my working paper (Cook, 2013).)

3. Data

This paper uses confidential data from the International Price Program (IPP) of the Bureau of Labor Statistics (BLS) which can only be accessed on-site in Washington, DC. This data set includes item-level prices for US imports and exports for the years 1994–2009. An excellent description of this data is available from Gopinath and Rigobon (2008). The BLS defines an item as the unique combination of a specific good from a specific importing or exporting firm.

In the BLS IPP data, some items are discontinued in the sample. Almost all items are intended to remain in the sample for five years,

[2] This is the same approached used by Feenstra (1989) to find a general equation for exchange rate pass-through with firms that face the same costs (as in Krugman (1980)).

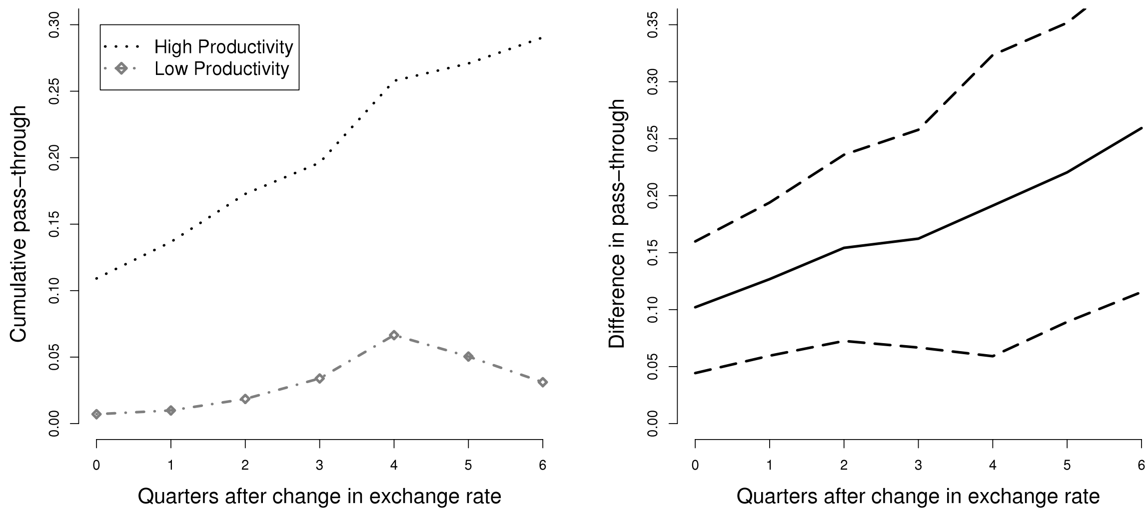

Fig. 1. Difference in pass-through for imports. In the left panel, cumulative exchange rate pass-through for high-productivity imports represented by the top line; cumulative exchange rate pass-through for low-productivity imports represented by the bottom line. In the right panel, difference in cumulative exchange rate pass-through between low- and high-productivity imports. The dotted lines are a 95% confidence interval.

but only about one third of the items do so. One of the BLS codes for why an items leave the sample is "Out of scope, not replaced", meaning that the item is no longer traded or is no longer produced. (A more detailed description of the BLS IPP data is provided in my working paper (Cook, 2013).)

The BLS IPP dataset provides a natural way to separate higher-productivity items from those with lower productivity. Items that are closer to the cutoff level of productivity are more likely to be forced to exit when trade conditions change. In addition to a change in the productivity cutoff, there are other reasons that items leave the market, for example a taste shock. The items that are traded for shorter periods of time will have lower average productivity as long as non-trade shocks are not related to productivity. We refer to items that do not leave the index early as higher average productivity, while items that are "Out of scope, not replaced" are lower average productivity. Empirical work has found evidence that firms that stop exporting have lower productivity than those that continue to export (Girma et al., 2003).

Because there is a great deal of price rigidity, regressions are run on quarterly data. Price imputations are common in this data. The two most common methods of imputation are "pulling forward" the last observed price and assuming that the price of the good changed along with other items in the same classification group (Feenstra and Diewert, 2001). Following Nakamura and Steinsson (2012), I replace all imputations with pulled forward imputations.

A large percentage of the items are intra-firm. Since our motivation for looking at items of different productivity comes from a model of market transactions, we limit our analysis to market transactions. We will also limit our analysis to differentiated products as our theoretical model is based on differentiated products. We use Rauch's (1999) classification of differentiated products and the concordance of Pierce and Schott (2009). This paper also uses exchange rate, consumer price index, and producer price index data from the International Monetary Fund's International Financial Statistics.

4. Differences in pass-through

A model of heterogeneous firms predicts that price is determined as stated in Eq. (1). Taking the natural logarithm of this equation and first differencing to correct for non-stationarity in the variables, we obtain

$$\Delta \ln(\text{price}) = \Delta \ln[(\text{markup} + 1) \times (\text{exchange rate}) \times (\text{cost})],$$

where Δ denotes a first difference. The produce price index (PPI) is used to proxy for changes in cost. Lags of changes in the exchange rate are also added because price responses to changes in the exchange rate are known to be slow. This leads to the following regression equation:

$$\Delta \ln(\text{price})_{i,k,t} = \delta + \sum_{j=0}^{6} \beta_{i,k,j} \Delta \ln(\text{exchange rate})_{k,t-j} + \kappa \Delta \ln \text{PPI}_{k,t} + \psi_{i,k,t},$$

where PPI is PPI in the producer's country. The subscripts i, k and t denote item, country, and time, respectively. The coefficient for the exchange rate varies by item, because adjustment to markup varies by item. If we include an item fixed effect and force the coefficient on the exchange rate to be the same for all items, we obtain

$$\Delta \ln(\text{price})_{i,k,t} = \delta_{i,k} + \sum_{j=0}^{6} \beta_j \Delta \ln(\text{exchange rate})_{k,t-j} + \kappa \Delta \ln \text{PPI}_{k,t} + u_{i,k,t},$$

where $u_{i,k,t} = \psi_{i,k,t} + \sum_{j=0}^{6} (\beta_{i,k,j} - \beta_j) \Delta \ln(\text{exchange rate})_{k,t-j}$. We use real price and the real exchange rate (RER) to control for changes in the price levels. Dummy variables are included for quarter, T, to control for seasonal effects:

$$\Delta \ln(\text{real price})_{i,k,t} = \delta_{i,k} + \sum_{j=0}^{6} \beta_j \Delta \ln(\text{RER})_{k,t-j} + \kappa \Delta \ln \text{PPI}_{k,t} + \sum_{k=2}^{4} \theta_k T_{k,t} + \mu_{i,k,t}. \quad (4)$$

Using quarterly data, Eq. (4) is estimated for low- and high-productivity imports and exports. Again, we are using the length of time that the item was in the BLS sample to define items as low- or high-productivity (as described in Section 3). Cumulative pass-through after N quarters is given by $\sum_{j=0}^{N} \sum \beta_j$.

For both imports and exports, pass-through is estimated simultaneously for both low- and high-productivity items using the seeming unrelated regression (SUR) model proposed by Zellner

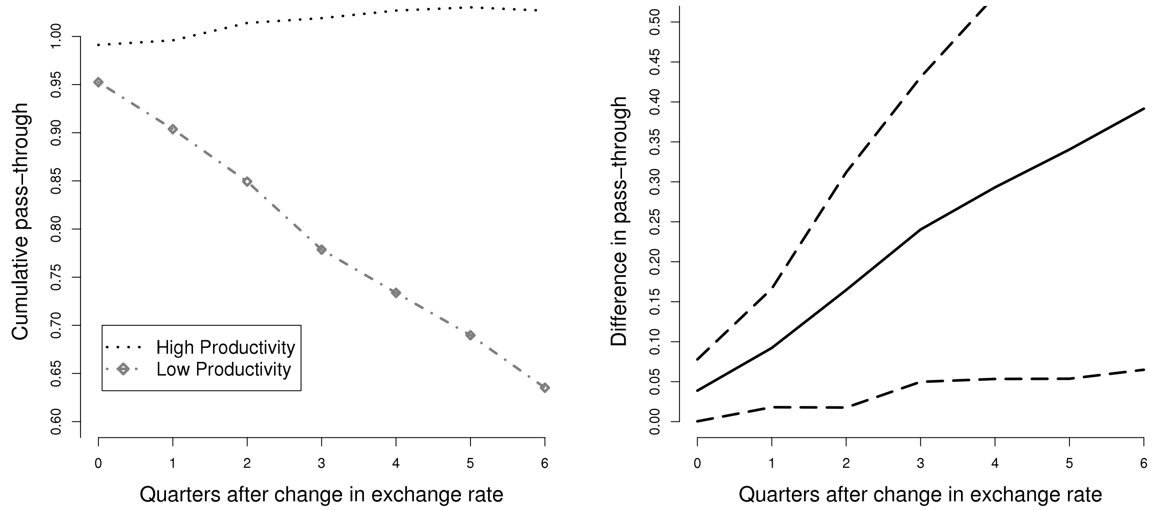

Fig. 2. Difference in pass-through for exports. In the left panel, cumulative exchange rate pass-through for high-productivity exports represented by the top line; cumulative exchange rate pass-through for low-productivity exports represented by the bottom line. In the right panel, difference in cumulative exchange rate pass-through between low- and high-productivity exports. The dotted lines are a 95% confidence interval.

(1962). This provides an estimate of the covariance of pass-through between low- and high-productivity items.

Figs. 1 and 2, show differences in cumulative exchange rate pass-through for low- and high-productivity items. High-productivity imports pass through roughly 25% more of the change in the exchange rate; high-productivity exports pass through about 40% more.

5. Conclusion

The finding of less pass-through for lower-productivity exports is consistent with a heterogeneous firm model in which higher-productivity firms have more stable markups, as would be the case with translog preferences. Under these preferences, lower-productivity firms have more elastic markups than higher-productivity firms. This finding is in contrast with the prediction of a heterogeneous firm model in which firms face linear demand.

This type of heterogeneous firm model provides an explanation for the decrease in the exchange rate pass-through to US import prices. As trade costs decrease, there is an increase in the number of low-productivity exporters, which exhibit less exchange rate pass-through.

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